DEVELOPMENTS IN WATER TECHNOLOGY AND CHANGING SOCIAL RELATIONS IN RURAL PUNJAB: A REVIEW

The relationship between technology, water and society is complex. Water is indispensable resource for agriculture. Though groundwater is a common resource, access to it depends on mode used for its extraction and control over water technology. By water technology here we mean the technology used for harnessing ground water for irrigation. The study is to delineate the effects of diffusion and adoption of new mode of technology on the nature of social relations.

The scholars who have devoted their energy and expertise to the understanding of the role of water technology in shaping agrarian social relations are covered in the chapter. Different dimensions of water technology which inform and intimate the changing social relations are undertaken. Efforts are made in the chapter to cite studies on traditional modes of irrigation and find out reasons which gave way to adoption of new water technology for irrigation. Developments in water technology and its implications on other variables like social relations, landholding, occupational diversification etc. are also discussed.

1. Studies on historical underpinnings of traditional mode of irrigation

Historically, irrigation source was commonly in the form of wells and canals in Punjab. But during the last five decades there has been a rapid change in irrigation system in the state in particular and India in general. In Punjab, charas was the traditional mode of irrigation which later on gave way to hult and then to tube-well and submersible pumps. However subsistence agriculture for self-producing villages and traditional technologies provided enough water for irrigating the indigenous varieties. Later establishment of British rule brought changes in agrarian society and in mode of irrigation in agriculture which directly affected the economy.
Under British rule, construction of several irrigation projects took place which expanded the state’s agriculture that has experienced momentous changes with transformation in mode of irrigation and agriculture. The relations of production in agriculture have been drastically affected with new irrigation projects. The wells have lost much of their importance since the introduction of extensive canal irrigation. Without its canals the Punjab would be unable to support its population (Census of India 1921).

After independence, one of the major factors which contributed to transforming Punjab’s socio-economic structure was Green Revolution. For the first time in the history of Punjab, capital intensive technology was introduced. With the advent of new package, demand for regular supply of water for irrigation has increased. Trend in irrigation technology changed again with the introduction of HYV crops. Irrigation requirements of these crops led to development of an alternative source of irrigation, that is, tube-wells (Kohli 1997). The farmers of Punjab adopted this Revolution to augment their earnings but it accompanies other problems like falling water table, declining soil fertility etc. (Shiva 1991). (Details in Chapter III)

2. Studies on developments in water technology and Green Revolution

We have discussed the concept and consequences of Green Revolution in detail in the third chapter. So to avoid the repetition we are discussing here its role as a driver of new water technology. Green Revolution crops required regular irrigation which was met by the creation of additional irrigation facility. The traditional irrigation systems like canals lack the kind of reliability and flexibility generally commanded by tube well irrigation (Singh 2003, p. 21). Jairath (1985) also concluded that the private tube-wells were the demand of Green Revolution.
In the early 20th century there was a spurt in expansion of protective rather than productive irrigation works (Reddy 1998). According to Dhawan (1990) irrigation from tube-wells is a perennial source of water for the farmers and therefore, permits crop activity in rain-deficit seasons with minimum risk. A study on farmer managed irrigation systems in northern Bihar notes that tube wells are the most reliable technology of irrigation while canal irrigation and rainfall were viewed as unreliable (Raju et al. 1999). The upward trend in the production during Green Revolution affected the social life of the farmers.

Dharmadhikary asserts:

The primary driver of tube-well based irrigation was the HYV seeds which required assured supply of water and were sensitive to the timing of waterings. While canal irrigation certainly was helpful with the new seeds, it could hardly provide the kind of assured supply required by them. Increasingly, the farmers in Punjab, and then in Haryana turned to groundwater irrigation. (Shripad Dharmadhikary 2007, p. 2)

The insufficient canal and rain water created pressure on groundwater. The *Fourth Plan document* – which came out in 1969 – after just a few years of experience of the HYV seeds has noted this phenomenon.

...ground water provides the farmer with just the type of ‘instant’ and controlled irrigation which the new high-yielding varieties of seed demand. This fact, coupled with the increasing extension of electricity to rural areas, explains the expansion which has taken place in recent years in the development of ground water resources. The expansion has taken place not only in areas which are without any other source of irrigation but also in alluvial tracts already commanded by existing canal systems;... The remarkable development of ground water resources during recent years was stimulated by the droughts of 1965-66 and 1966-67 which also happened to coincide with the development of...
high-yielding varieties which perform best under conditions of controlled and timely irrigation. (Dharmadhikary 2007, p. 3)

Singh (2001) has observed that installation of fresh water technology was a precautionary measure. The sinking of tube wells in the latter half of the 1960s and first half of the 1970s became the main stay for irrigation. The waiting list for tube well connections has increased from 24,636 in 1966 to nearly 262,000 in 1990-91 before subsiding marginally thereafter (Statistical Abstract of Punjab). Therefore increased utilization of tube-wells was due to Green Revolution.

S. V. Ciriacy-Wantrup found

The Green Revolution has created a need for more water. Groundwater tables are beginning to fall and will force the replacement of the Persian wheel by deep-well pumps… Water allocation problems between users, between uses, between states and regions, between areas of origin and areas of destination, and between state and federal jurisdictions loom on the horizon. (Ciriacy-Wantrup 1969, p. 1322)

It is clear from above statement that Green Revolution accompanied other new serious problems. It commenced commercialization of agriculture where new water technologies like tube well and later submersible acted as a catalytic agent. Thus we can say that major technological advancements in irrigation are a result of the Green Revolution.

3. Studies on new water technology and its economic consequences

“The economists have been active, particularly in the early years of the Green Revolution, in doing ex post analysis relating to the profitability of new packages, factors influencing the adoption of new technology and how the gains from technology are distributed. But they ignored the long term consequences of such
innovation” (Rao 1989, p. 385). Thus the serious consequences on other spheres were ignored.

According to Raju et al.

Tube wells are responsible for diseconomies on farmers. In the long-run, farmers with tube wells experience low variable cost and as a result they permanently lower water table. This has a significant negative externality on farmers dependent on human/animal operated traditional irrigation structure (that have limitations on the depth at which groundwater can be exploited). (Raju et al. 2004, p. 275)

After 50 years of adoption of Green Revolution, a report in the magazine *Frontline* 24 (14) in 2007 gauged the critical situation of farmers in Punjab.

Until about 1955, Chamkaur Singh's well had the Persian wheel and bullocks. A motor was installed in the well in 1968. In 1975, the family dug a tube well at 45 m; in about 10 years, it got worn out. A new well was sunk at a new spot, at 60 m. In 2006-07, he got a 15 hp (horsepower) motor installed 120 m down. (*Frontline* 2007, p. 3)

Groundwater has been extensively used for irrigation and time to time technology was upgraded for its further exploitation. New water technology is not affordable to all the classes of peasants. Those who cannot afford the extra investment may be forced to give up well irrigation and thereby lose out to the better endowed farms (Janakarajan and Vaidyanathan 1997). A high- capacity pump may create a cone of depression that dries up surrounding shallow pumps (Dubash 2002).

A Report in India’s national magazine *Frontline* 24 (14) in 2007 showed the side effects of new pump technology on the individual as well as the village. “The village was put up for sale on July 2, 2005, since we had no canal water and the groundwater was saline. If we use this water, the soil turns barren,” said Jasbir. “One tube well
costs Rs.4 lakh around here. My own well is 365 m deep” (Frontline 2007, p.2). Only well to do farmers can install technology others can not.

Vaidyanathan (2006) pointed out financial constrain in deepening the well forced small and marginal farmers to give up well irrigation and there by lose out to the better endowed farms. Thus the discourse of change in water technology favoured well off farmers.

While comparing the old irrigation technology with new water technology Dhawan (1982) has argued that small amount of capital required for dug wells makes them conducive to private ownership by small farmers, the lumpiness of investment in deep tube-wells precludes their ownership by private individuals.

A study by Nagaraj et al. (2003) showed that small farmers are badly affected because they have not been able to spend money on deepening the wells or installing the additional well or investing in some other coping mechanism. On small farms only 28 percent wells were functional while the percentage of functioning wells was 38 and 41 on medium and large farms respectively. This new technology could be individually owned and operated thus this new independent mode of irrigation created rise in individualism.

4. Studies on water technology and its effects on social relations

It is however, argued that in the struggle for irrigation water in post-Green Revolution increased. Thus, it is imperative to study the social consequences of new water technology. The studies covering this area are mentioned below.

Kees and Kees De Jong (1991) found that the (irrigation) technology makes market relations essential, because inputs have to be acquired and (product) has to be sold. They further pointed at the role of irrigation technology in increasing process of
commoditization, thereby facilitating capital accumulation and social differentiation. Freidmann (1980) marked that as commodity relations deepen, particularistic ties give way to market logic, and extraction is accomplished through market exchange.

Marx delineated that with change in mode of production, the relations of production also change. This new pump technology offered opportunity to its owner to increase capital accumulation. Hence it led to commodification of water resource and relations. Lindberg (1996) in his paper showed that, how individual rationality conflicts with collective rationality and eventually results in the erosion of common property resources.

Janakarajan and Moench (2006) studied the depletion of water table and its acute implications. The study found that in final stage the costly technology can extract water from deep aquifers and the implication is inequality, conflict, competition and, above all, to indebtedness and poverty. The relations got strained with depletion of water table. The main effect of depleting water table is adoption of new technology which shapes the social relations in rural society. The study noticed that with declining water table tank irrigation declined trend of private and shared tube wells emerged. Finally they throw light that it became a reason of adverse social relations.

(i) Emergence of Groundwater market

One of the striking aspects of new water technology is emergence of groundwater market. This section unfolds the emergence of water market in India as a whole but not in Punjab since no study has been conducted thus far. It also focuses on the emergence of new patterns of water sharing and their management as a result of such developments in water technology.
New technology necessitated new system of its ownership and management. The traditional water harvesting systems were based on exchange and reciprocity while the new ones demand formal relations of market in terms of cash payments. Thus new water technology has generated a new system of water distribution or what we may call the water market.

With the emergence of individual pumps the private pump owners are pumping water for sale to those who do not have access to water for irrigation (Saleth 1994). Formal and informal markets have emerged. In water market pump owners often reinforce their position as “water lords” in the rural society (Janakarajan 1994). Banerji et al. (2006) argued further that “monopoly power is higher if there is low tube-well density and if unlined water channels ‘compel’ farmers to purchase from the nearest tube-well” (Banerji et al. 2006, p.2).

Traditional irrigation structures have a history of being locally managed through village assemblies (Sengupta 1985). A traditional farmer’s agriculture and economic needs are well complemented by these structures to ensure long-run sustainability of the system (Raju et al. 2004). The traditional system was self-sufficient and did not require any institution or market for fulfillment of needs.

Putnam makes an argument that norms of reciprocity and network of civil engagement give rise to social capital which make co-operation between people possible (Hariss and De Renzio 1997). Emergence of groundwater market delineates the capitalistic reciprocity and profit oriented exchange. David Hardiman (1998) noticed that

In the past, wells hardly ever dried up entirely, even in years of severe famine. Only during the 20th century it has become possible to bore deep tube-wells, and to pump the water out using submersible pumps. At the same time an insatiable demand for
water has been created by Green Revolution agrarian technology, involving high-yielding hybrid crop varieties which need a massive amount of watering. The demand is satisfied by those who have sufficient resources to construct tube-wells and pump out and sell water to their neighbours. (Hardiman 1998, p.244) (emphasis added)

Shah cites several examples of groundwater market and its externalities on others.

The owners of grape orchards in Karnataka and Andhra Pradesh, for instance, are known to buy up neighbouring lots at premium prices to solve the problem of interference…in many parts of Gujrat, where localized water markets have assumed highly sophisticated forms, it is common for a well owner to lay underground pipelines through neighbours’ fields at his own cost, and dissuade them from establishing their own wells by informal long-term contracts for supply of water at mutually agreed prices. (Shah 1993, p. 7)

(ii) Groundwater market and social relations

Jacoby et al. (2004) examine the extent of monopoly power exercised by tube-well owners, and whether they price-discriminate in favour of their tenants, in Punjab, Pakistan. No system can hope to be useful unless it has first understood the social relations and categories of meaning involved. Although few studies have looked at the social dimension of depleting water table and implications of new water technology on social relations.

Bela Bhatia (1992) also marked the role of new technology in bringing market relations that resulted in the emergence of inequality and over-exploitation. She mentioned that large farmers own groundwater resource and use it to exploit others. Dubash’s (2002) analysis highlights the role of social norms in negotiating water contracts; he suggests, for example, that a ‘moral’ economy operates to prevent sellers from setting anything substantially more than a commonly perceived ‘fair’ price. In
water market the moral system operates for taking benefit. Mudrakartha stated about such condition that “farmers are compelled to respond and adapt to these changes in a variety of ways to keep the hearth burning, ever at the cost of disruption of their social and family life” (2007, p. 244). Farmers are so desperate for new water technology that they sell their topsoil to brick kilns to pool resources for irrigation (Moench and Dixit 2004; Mudrakartha et al. 2004a).

It was observed that the relations with one’s own field neighbours turned into market relations. Jairath (1985) outlined the implications of tube-wells in Punjab and stated that joint tube-wells reduce the cost and risk but it is useful only in case of owners of contiguous areas who would find it mutually beneficial. In context of purchasing water from tube-wells he mentioned that purchasing water deal is struck on an individual irrigation basis and there is no commitment on the part of the seller to provide a certain minimum throughout the crop season. Again the water is sold by the owner only after satisfying his own needs depending on his cropping pattern. The same inferences were put down by Bhatia (1992) and Dubash (2002) in their studies.

Bhatia also found out that pump owners often lease-in the land from those without pump. “Those who own productive assets such as pump sets are themselves increasingly keen to take land on lease, so as to make full use of these assets” (Bhatia 1992, p.A-153). As a result of these mutually reinforcing factors, the poor are gradually losing the limited cultivation opportunity they used to have (Sharma and Dreze 1990).

Ghate (1980) documents, shared investment and ownership of tube-wells in Uttar Pradesh, but notes that the arrangements frequently dissolve when confronted with pressures such as electricity shortage and the desire to shift cropping patterns. But its social effects on relations were not discussed in detail by the scholar.
Bhatia viewed groundwater market as an option through which rich became more rich. “It is another source of increasing inequality and of greater dependency of the assetless on the more resourceful farmers” (Bhatia 1992, p. A-156). While some scholars view that sale of water via water market is a major contribution in the equitable distribution of groundwater in Gujarat (Shah 1987; Kolavalli and Chicoine 1987).

Dhawan (1993) state it the proliferating privately owned tube-wells. Some authors have even argued that these water markets make a major contribution to the equitable distribution of groundwater in Gujarat (Shah 1987; 1989). Dubash (2002) marked that

Many wealthy farmers see groundwater exploitation as a route out of agriculture, if not for them, then for their sons. For less wealthy well owners (pump owners) who are likely to be left behind, there is no choice but to extract as much as they can for as long as they can. Thus surplus generated from farming and groundwater sales is increasingly being used to diversity into urban economic opportunities such as small scale industry and retail enterprises. This trend is supported by a broader cultural shift in attributed to agriculture (ibid. 2002, p. 48). (emphasis added)

Selling of water to needy farmers was not earlier present. Study by S.V. Ciriacy-Wantrup found that:

What is the effect of these fundamental differences in the irrigation economy on the development of water institutions? In a diversion economy, water institutions—such as water rights, water districts, a water master, and public agencies engaged in building, main-taining, and operating facilities—are a necessary condition from the beginning. In a water economy based on the Persian wheel, such institutions are not needed and do not develop. Groundwater institutions become a necessity only when water use by one farmer affects his neighbour. This happens when the Persian wheel is replaced by modern deep-well pumps. Here the neighbor is
affected by the pumping cone and by the seasonal and often secular depletion of the resource because of high-capacity pumps. (Ciriacy-Wantrup 1969, p. 1321)

It delineates the changing agrarian social structure. The changing mode of irrigation is affecting the social behavior and relations.

5. Studies on water technology and women’s participation

The participation of women also got changed after new irrigation technology. Krishnaraj and Amita Shah (2004) mentioned that as population increases and the size of landholdings diminish continuously with division and subdivision, the family household can no longer manage with only subsistence production. Women then are forced to seek wage labour. In the prosperous landed families women are withdrawn from outside labour to establish family status.

Similar observations have been made by Abbi and Singh in respect of Jat women’s participation in the family agriculture in village Barwali Khurd.

Formerly their active supporting role in the fields at the time of irrigation, harvesting, weeding, cutting of fodder, picking of cotton, sowing, feeding animals and providing food for the family members and the hired men, was not only substantial but also a necessary and important complement to men’s work. Now this participation is confined to the vicinity of the home and generally takes the form of either looking after the milch animals tethered in the animal shed at home or supervising such looking after by the hired hands. (ibid. 1997, p.34)

6. Studies on water technology and size of landholding

Size of landholding is an important factor influencing the adoption and control over water technology. Gill writes that small and marginal farmers between 1970-71 and 1980-81 large number of such holdings have disappeared…The decline is 25.3 per cent. This decline is contributed solely by marginal and small holdings. The marginal
holdings declined by 61.9 percent, and small holdings declined by 23.3 percent (Gill 1997).

The reason given by Kalkat et al. (2006) that the marginal farmers are leasing out their land in distress and without any quality alternative employment in rural areas find it ever harder to live. Sukhpal Singh (2010) mentioned that there is direct relationship between the size of landholding and adoption of technology. A study in Tamil Nadu indicates that access to groundwater has almost replaced land in determining one’s socio-economic and political status (Janakarajan 1992; 1997a). He further stated that nevertheless in changing agrarian context, it is the ownership of wells (new irrigation technology) along with land, which determines one’s status. Growing inequality in access to groundwater leads to a process of continued social differentiation, which results in deprivation, poverty and the consolidation of inequitable power relations within local communities (Janakrajan and Moench 2006).

Dhawan (1982) calculated the threshold size for a farm to viably utilize a shallow tube-well. Bhatia (1992) pointed that size of landholding is a major reason for why many poor farmers cannot make investments in owning a new pump. A study by Dhawan marked that

Small scale irrigation works that are heavily dependent on family labour in their construction and operations are better suited to the resource endowment of small farmers. On the other hand, irrigation works that require minimal use of human or animal labour but make a heavy demand on the scarce capital resource are better suited for large farmers…after all pumpsets and tube-wells are quite indivisible investment that prove uneconomic for farmers below a certain farm size unless they can surmount the investment indivisibility by the cooperative use of such investments. (ibid., 1998, p. 277)
Dubash (2002) pointed out that large farmers adopt the technology where as small farmers often have less access to it. Thus it also leads to social polarization. Scholars pointed that due to small landholding and non-ownership of pump peasants faced problems like indebtedness, leasing-out land, etc. Whitcombe (1971) explains how irrigation led cropping changes focus towards commercial crops leading small peasants into credit trap.

There was about 11 lakh numbers of operational holdings in Punjab of which about 45 percent were smaller than 2 hectares in 1990-91. The number of such holding came down to 35 percent in 1995-96, and further to less than 30 percent in 2000-01, which is reflective of the reverse tendency. The marginal (and small) farmers are leasing out their land in distress (the total number of operational holdings is now less than 10 lakh) and join the rank of labourers. This has serious repercussions for the rural society in Punjab. (Singh 2010, p. 213)

Janakarajan and Moench (2006) raised the same point that inequity in access to groundwater leads to a process of continued social differentiation, which results in deprivation, poverty and the consolidation of inequitable power relations within local communities. Access to groundwater can play a major role in poverty alleviation and has done so in India (Moench 2001) because it reduces agricultural risk. Such studies also outlined the ownership of technology as a crucial factor in agriculture along with land.

7. Studies on water technology and crop selection

Role of changing water technology on crop selection and production is imperative to discuss. Availability of water determines selection of crops. Regular and frequent water can only be available via new technology. So it plays a significant role in crop selection and for high yield. A study by Raju et al. stated that
Advantage of this (pump) technology is that it improves the cropping intensity of farmers who otherwise would have been exclusively dependent on rainfed agriculture. Furthermore, farmers using this technology have the ability to grow crops they would not have been able to grow earlier. As a result of adoption of (pump) technology beneficial impact are also seen on cropping intensity, cropping patterns and crop yield and as a result of increase in these intermediate variables, income levels of farmers increase significantly. (Raju et al. 2004, p. 276)

The change in land utilization and cropping pattern was materially affected by the rapid introduction of tube-wells. There were 4799 tube-wells in 1956-57 that increased to 29,684 in 1964-65; mainly privately owned. The greatest factor in bringing about this change was the application of science and technology to agriculture. With electricity coming to villages, tube-wells and pumping sets multiplied; mechanization of agriculture with tractors and threshers, become common (Chopra 1985, p. 566).

Kessinger (1974) pointed that the traditional elements such as the jajmani system, which regulated economic relations between landowning labour/service caste, in terms of traditional obligations and where payments were in kind, had been overtaken by cash transaction in the Doaba region. It was considerably muted elsewhere in Punjab.

8. Studies on water technology and occupational diversification

Although the main focus of this study is on social relations, it is important to place emphasis on the result of new water technology. Those peasants with small landholdings who did not own pump for irrigation faced difficulty in sustaining agriculture. Thus to keep their hearth burning they either opt out of agriculture and get into some other profession or made it a secondary one. Due to non-viability of small farms about 2 lakh small farm families left farming between 1991-2001 (Singh et al.
2007). The marginal and small farmers are leasing out their land in distress and are joining the ranks of labourers (Singh 2010).

It is analyzed that large peasants who have water technology and doing well in agriculture lease out their land and get into politics or other business. Roy (1975) pointed out that prosperity from an increase in agriculture output due to technological change resulted in out migration from agriculture.

A study by Abbi and Singh (1997) mentioned that the jajmani system was significantly eroded and traditional village artisan castes, after firstly taking to agricultural labour, upgraded their entrepreneurial skills and educational labour to move into variety of new occupations. The discussion mentioned that one of the implications of new water technology is occupational diversification.

**Summing up**

The review of the studies conducted abroad and in India on role of water technology enables the researcher to summarize that water technology plays an important role in influencing social relations as well as production. New costly water technology has changed the hitherto existing social institutions. It has also resulted in the depletion of water table and emergence of water market.

Most of the above mentioned studies throw light on different dimension of new water technology like affects on water management, economic consequences, water market etc.